Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, DC

TSO-C146

Date: 10/06/99

Technical Standard Order

Subject: Stand-Alone Airborne Navigation Equipment using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)

1. PURPOSE. This technical standard order (TSO) prescribes the minimum performance standard that stand-alone airborne navigation equipment using the Global Positioning System (GPS) augmented by the Wide Area Augmentation System (WAAS) must meet in order to be identified with the applicable TSO marking.

2. APPLICABILITY. The standards of this TSO apply to equipment designed to accept a desired flight path and provide deviation commands referenced to that path. These deviations will be used by the pilot or autopilot to guide the aircraft. These standards do not address integration issues with other avionics, such as the potential for the system to inadvertently command an autopilot hardover. These standards also do not address the use of position information for other applications such as automatic dependent surveillance.

3. REQUIREMENTS. Airborne navigation sensors using GPS augmented by WAAS that are to be identified with the marking "TSO-C146" must meet the minimum performance standards for Class Gamma or Class Delta equipment set forth in Section 2 of RTCA/DO-229B, "Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Equipment," dated October 5, 1999. Class Gamma and Class Delta equipment are defined in Section 1.4 of RTCA/DO-229B.

a. Failure Condition Classification. Failure of the function defined in paragraph 3 of this TSO has been determined to be: a major failure condition for malfunction of en route, terminal, or nonprecision approach navigation data and a hazardous failure condition for the malfunction of precision approach navigation data. The applicant must develop the system to at least the design assurance level commensurate with this hazard classification.

b. Functional Qualifications. The required performance shall be demonstrated under the test conditions and procedures specified in RTCA/DO-229B, Section 2.5. The use of test procedures other than those specified in Sections 2.5.2 through 2.5.9 of RTCA/DO-229B constitutes a deviation to this TSO.

c. Environmental Qualifications. The equipment shall be subject to the test conditions as specified in RTCA/DO-160D, "Environmental Conditions and Test Procedures for Airborne Equipment," dated July 29, 1997.

d. Software Qualifications. If the article includes software, the software must be developed in accordance with Sections 3-11 and Annex A of RTCA/DO-178B, "Software Considerations in Airborne Systems and Equipment Certification," dated December 1, 1992. If the software is qualified using criteria contained in Section 12 of DO-178B, TSO applicants must apply for a deviation to this TSO.

e. Vertical Navigation (VNAV). If the equipment provides VNAV based on a barometric input, it must meet the requirements in Appendix F of RTCA/DO-229B.

f. Barometric-Aided Fault Detection and Exclusion (FDE). If the equipment uses barometric-aiding to enhance the availability of FDE, it must meet the requirements in Appendix G of RTCA/DO-229B.

4. MARKING. In addition to the markings specified in 14 CFR § 21.607(d), the following requirements apply to all separate components of equipment that are manufactured under this TSO:

a. At least one major component must be permanently and legibly marked with all of the information listed in 14 CFR § 21.607(d).

b. Each separate component of equipment must be permanently and legibly marked with at least the name of the manufacturer, manufacturer's part number, and the TSO number.

c. If the component includes software, the part number must include hardware and software identification, or separate part numbers may be utilized for hardware and software. The part number must uniquely identify the hardware and software design, including modification status.

d. The operational equipment class as defined in Section 1.4.2 of RTCA/DO-229B (e.g., Class 2). A marking of Class 4 indicates compliance to Delta-4 requirements. The functional equipment class defined in Section 1.4.1. of RTCA/DO-229B (e.g. Gamma, Delta) is not required to be marked.

e. When applicable, identification that the article is an incomplete system or that the article accomplishes additional functions beyond that described in paragraph 3 of this TSO.

5. DATA REQUIREMENTS.

a. Data to be provided with the application. In addition to documents specified in 14 CFR §§ 21.605(a)(1) and (3) and in accordance with § 21.605(a)(2), the manufacturer must furnish the Manager, Aircraft Certification Office (ACO), Federal Aviation Administration (FAA), having

purview of the manufacturer's facilities, one copy each of the following technical data to support the FAA design and production approval:

(1) Operating instructions and equipment limitations. The limitations shall be sufficient to describe the operational capability of the equipment. The operating instructions shall include:

(a) An operations manual that provides a reference on the use of the equipment.

(b) A training package to instruct the operator on the use of the equipment. This training package may use any medium (video, software, paper, etc.), and should familiarize the operator with all of the functions and operation of the equipment.

(c) A quick reference guide that contains instructions on how to accomplish at least the following operations: entering a flight plan; editing a flight plan; executing a Direct-TO; accomplishing a holding pattern; executing an approach procedure (Class 2/3/4 equipment); executing a missed approach (Class 2/3/4 equipment).

(2) Installation procedures and limitations. The limitations shall be sufficient to ensure that the article, when installed in accordance with the installation procedures, continues to meet the requirements of this TSO. The limitations shall also be sufficient to identify any unique aspects of the installation. The limitations shall include at least the following:

(a) A note with the following statement:

"The conditions and tests required for TSO approval of this article are minimum performance standards. It is the responsibility of those desiring to install this article either on or within a specific type or class of aircraft to determine that the article, when installed, performs in accordance with the design specifications that meet this TSO. The article may be installed only if further evaluation by the applicant documents an acceptable installation and is approved by the Administrator."

(b) Adequate specification of the interface between the GPS/WAAS equipment and other systems to ensure proper functioning of the integrated system. This must include maximum tolerable currents and voltages into the antenna port if the equipment is to be installed with a standard antenna (TSO-C144, "Airborne Global Positioning System Antenna" which references RTCA Document No. DO-228, "Minimum Operational Performance Standards for Airborne Global Navigation Satellite System Antenna.").

(c) If the equipment has only been demonstrated to satisfy the requirements of RTCA/DO-229B when used in conjunction with a particular antenna, the use of that antenna (by part number) must be specified as a limitation.

(d) If the equipment is dependent on any inputs in order to satisfy the requirements of RTCA/DO-229B (e.g., baro-aided FDE), those inputs should be made a requirement on the installation (i.e., a limitation).

(e) If the software qualification limits the equipment to be eligible on certain aircraft types, identification of the qualification level and identification that the equipment has not been determined to be eligible for all aircraft types (e.g., AC 23-1309-1A states that the DO-178B Level C software may be associated with a hazardous failure condition for certain aircraft types).

(f) When applicable, identification that the article is an incomplete system or a multi-use system. This must describe the functions that are intended to be provided by the article.

(3) Schematic drawings as applicable to the installation procedures.

(4) Wiring drawings as applicable to the installation procedures.

(5) Specifications.

(6) List of the components (by part number) that make up the equipment system complying with the standards prescribed in this TSO.

(7) Instructions for periodic maintenance and calibration that are necessary for continued airworthiness.

(8) An environmental qualifications form as described in RTCA/DO-160D for each component of the system.

(9) Summary of the database updating process that complies with the requirements in Section 2.2.1.5.3 of RTCA/DO-229B. This summary must identify the data source(s) and a brief description of the data distribution and update process.

(10) Manufacturer's TSO qualification test report.

(11) Nameplate drawing.

(12) A drawing list, enumerating all of the drawings and processes that are necessary to define the article's design.

(13) If the article includes software: Plan for Software Aspects of Certification (PSAC), Software Configuration Index, and Software Accomplishment Summary as required by RTCA/DO-178B.

> NOTE: The FAA recommends that the PSAC be submitted early in the software development process. Early submittal will allow timely resolution of issues such as partitioning and determination of software levels.

b. Data that must be available upon request. In addition to those data requirements that are to be furnished directly to the FAA, each manufacturer must have available for review by the manager of the ACO having purview of the manufacturer's facilities, the following technical data:

(1) The functional qualification specifications to be used to qualify each production article to ensure compliance with this TSO.

(2) Qualification test procedures used to determine compliance with this TSO.

(3) Equipment calibration procedures.

(4) Corrective maintenance procedures (within 12 months after TSO authorization).

(5) Schematic drawings.

(6) Wiring diagrams.

(7) The results of the environmental qualification tests conducted in accordance with RTCA/DO-160D.

(8) If the article includes software, the appropriate documentation as defined in RTCA/DO-178B, including all data supporting the applicable objectives found in Annex A of RTCA/DO-178B, Process Objectives and Outputs by Software Level.

(9) Documentation which describes the data distribution process in detail, compliant with RTCA/DO-200A, "Standards for Processing Aeronautical Data."

c. Data to be Furnished with Manufactured Units.

(1) One copy of the data and information specified in paragraphs 5(a)(1) through (9) of this TSO must be provided to each purchaser of one or more articles manufactured under this TSO.

(2) If the article accomplishes any additional functions beyond that described in paragraph 2 of this TSO, then a copy of the data and information specified in paragraphs 5(a)(9) through (12) that pertains to those functions must also be provided to each purchaser of one or more articles manufactured under this TSO.

6. AVAILABILITY OF REFERENCED DOCUMENTS.

a. Copies of RTCA/DO-160D, DO-178B, DO-200A, DO-228 and DO-229B may be purchased from RTCA Inc., 1140 Connecticut Avenue, N.W., Suite 1020, Washington, D.C. 20036.

b. 14 CFR Part 21, Subpart O, may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402-9325. AC 20-110 (current revision), "Index of Aviation Technical Standard Orders," and AC 20-115 (current revision), "Radio Technical Commission for Aeronautics, Inc., Document RTCA/DO-178B," may be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.

James C. Jones
Manager, Aircraft Engineering Division
Aircraft Certification Service